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STRUCTURES AND DYNAMICS DIVISION

RESEARCH AND TECHNOLOGY PLANS - FY-81

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National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

STRUCTURES AND DYNAMICS DIVISION

RESEARCH AND TECHNOLOGY PLANS - FY-81

By

Kay S. Bales

SUMMARY

The purpose of this paper is to present the Structures and Dynamics Division's research programs for FY 1981. The work under each branch/office is shown by RTR Objectives, Expected Results, Approach, and Milestones keyed to a logistics chart. This information will be useful in program coordination with other government organizations in areas of mutual interest.

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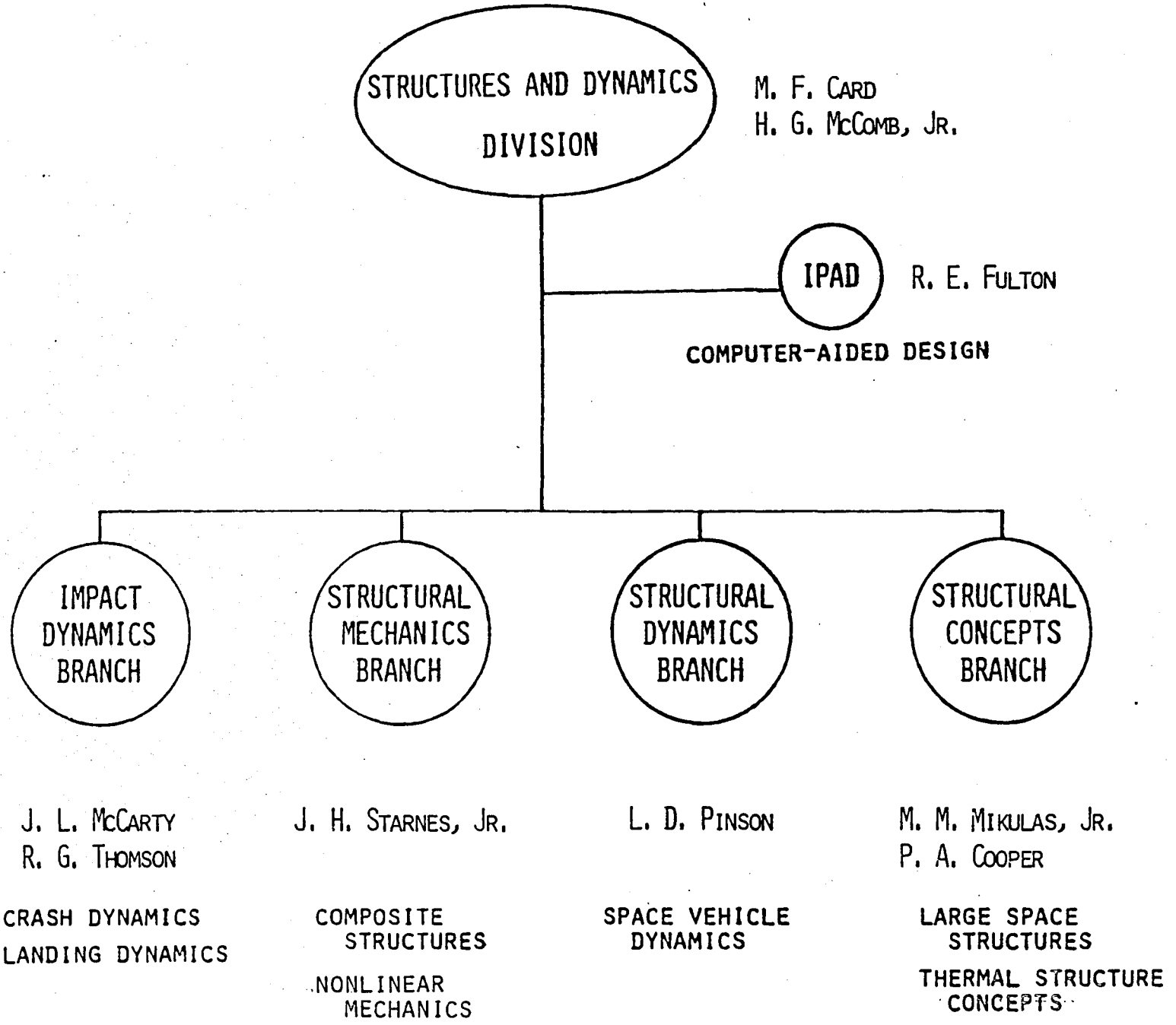
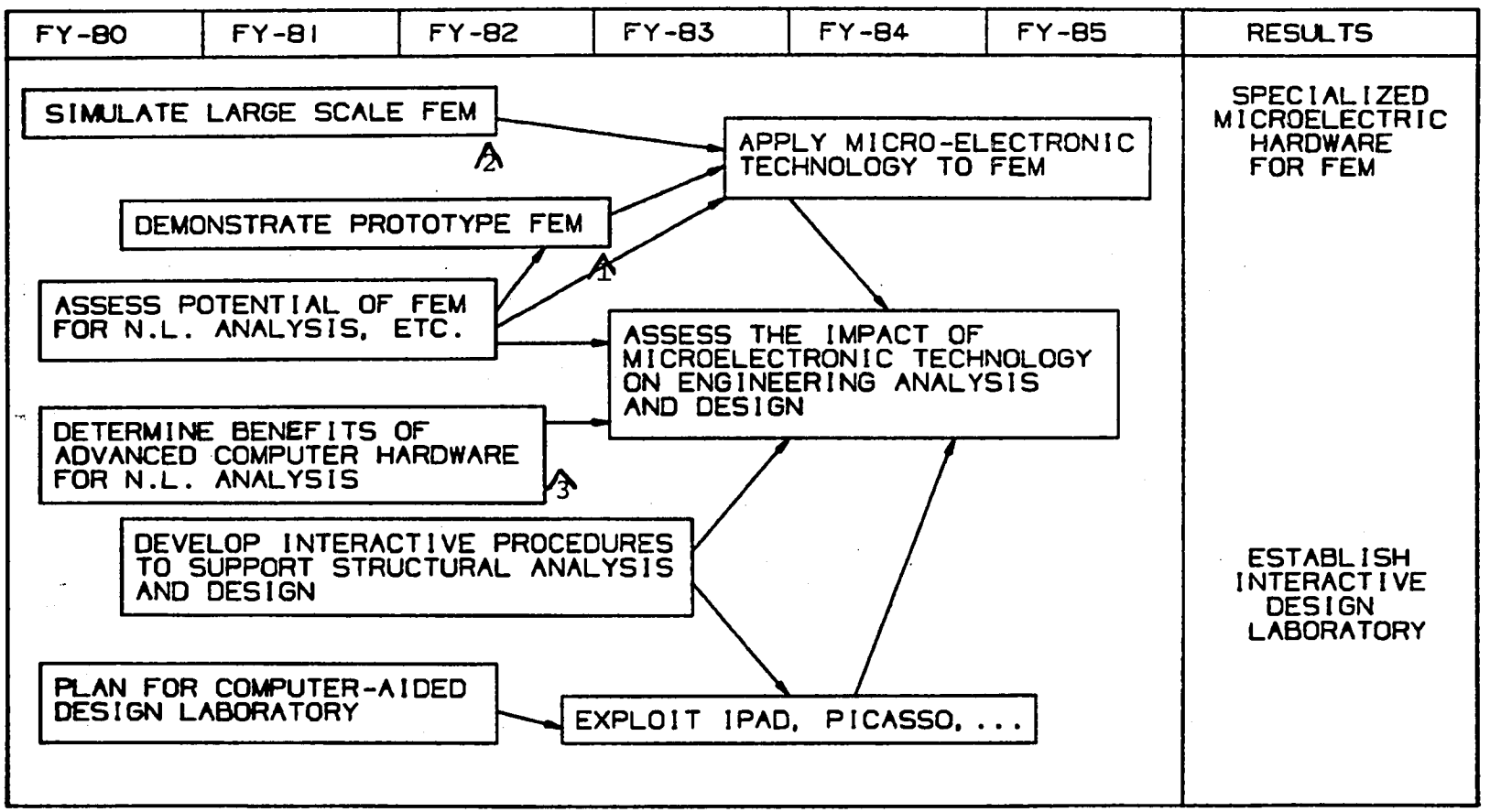


II IPAD PROJECT OFFICE

ADVANCED COMPUTER METHODS



II IPAD PROJECT OFFICE

RTOP 505-33-63 Aeronautical Structural Design Methods
RTR 505-33-63-01 Computer-Aided Design

OBJECTIVE:

Exploitation of advances in computer hardware and software to improve the efficiency of structural calculations

EXPECTED RESULTS:

- o Develop a prototype finite element computational device using microprocessor components which is capable of reducing computational times by a factor of 10 by end of FY 1981
- o Simulate large-scale finite element machine by end of FY 1983
- o Assess usefulness of man-in-the-loop methods for engineering analysis and design
- o Develop finite element computational devices using microelectronics by FY 1985

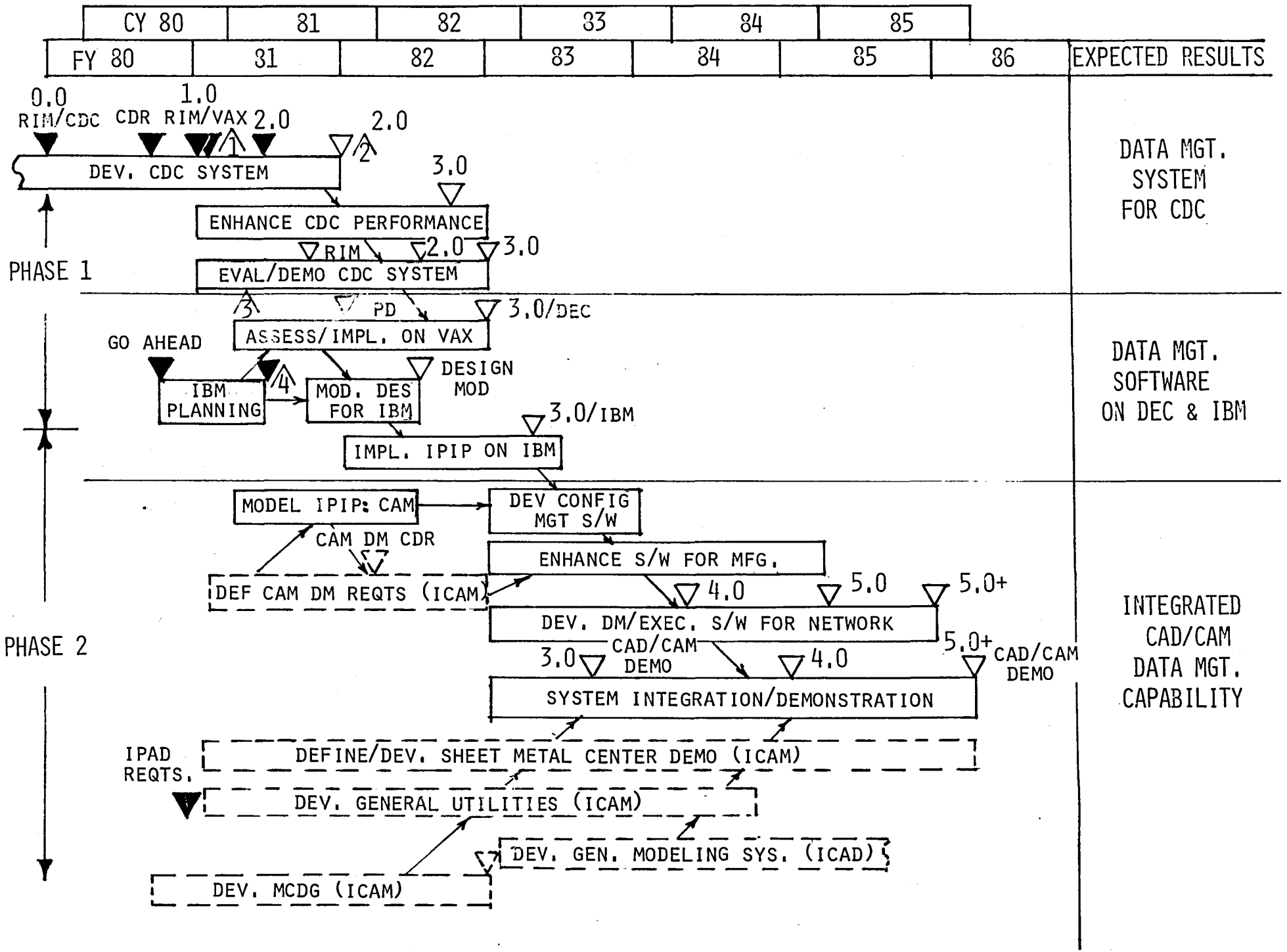
APPROACH:

In-house investigation of combinations of PRIME-400 and VAX minicomputers and CDC 6000 series mainframe are being conducted to improve the efficiency of structural calculations. Approaches are being studied to determine the optimum utilization of the combined capabilities of a distributed set of computer hardware. Studies of applications of microprocessors to structural calculations will be performed in cooperation with the Institute for Computer Applications in Science and Engineering at Langley. Specifically, definition of key components of a finite element computational device based on microprocessors will be accomplished, and design and fabrication of a prototype finite element machine to demonstrate the hardware efficiency will be carried out.

MILESTONES:

1. Have operational 36-node prototype finite element machine
2. Complete simulation of 1024-node finite element machine
3. Usefulness for interactive approach to nonlinear structural analysis

IPAD PLAN


CY 80
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FY 80
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EXPECTED RESULTS
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RIM/CDC
CDR
1.0
RIM/VAX
2.0
2.0
DEV. CDC SYSTEM
3.0
ENHANCE CDC PERFORMANCE
RIM
2.0
3.0
EVAL/DEMO CDC SYSTEM
PHASE 1
PD
3.0/DEC
ASSESS/IMPL. ON VAX
GO AHEAD
IBM PLANNING
MOD. DES FOR IBM
DESIGN MOD
3.0/IBM
IMPL. IPIP ON IBM
MODEL IPIP: CAM
DEV CONFIG MGT S/W
CAM DM CDR
ENHANCE S/W FOR MFG.
DEF CAM DM REQTS (ICAM)
4.0
5.0
5.0+
DEV. DM/EXEC. S/W FOR NETWORK
PHASE 2
CAD/CAM DEMO
3.0
4.0
5.0+
CAD/CAM DEMO
SYSTEM INTEGRATION/DEMONSTRATION
IPAD REQTS.
DEFINE/DEV. SHEET METAL CENTER DEMO (ICAM)
DEV. GENERAL UTILITIES (ICAM)
DEV. GEN. MODELING SYS. (ICAD)
DEV. MCDG (ICAM)
DATA MGT. SYSTEM FOR CDC
DATA MGT. SOFTWARE ON DEC & IBM
INTEGRATED CAD/CAM DATA MGT. CAPABILITY

IPAD PROJECT OFFICE

RTOP 510-54-13 Integrated Programs for Aerospace Vehicle Design (IPAD)
RTR 510-54-13-01 Integrated Programs for Aerospace Vehicle Design (IPAD)

OBJECTIVE:

To develop the preliminary design and a limited capability prototype (first-level IPAD) of a computer software system for total management of aerospace-vehicle design processes to be operational in the 1980's and providing reductions of 50 percent or more in design cycle time and 25 percent or more in design cost

- Provide significant system design which attains advances in the areas of engineering data base management and distributed computer network communication
- Demonstrate that the first-level IPAD will provide the above advances, as well as provide proof-of-concept software modules, in these advanced technology areas for use by the industry as components of in-house developments

EXPECTED RESULTS:

- Release, for industry evaluation, a preliminary version of phase one IPAD data base management system (DBM) by end of FY 1981
- Release a preliminary version of phase one IPAD with enhanced DBM by end of FY 1982
- Release final version of phase one IPAD by end of FY 1983
- Release preliminary version of phase two IPAD with multimachine network DBM by end of FY 1984
- Release completed prototype IPAD system by end of FY 1985

APPROACH:

The prime contractor has established the requirements and preliminary design for a comprehensive integrated computer-aided design (CAD) system of the future. From this design will be developed a prototype engineering data management system to support aerospace design. Software design will consider more than one computer with an initial implementation focusing on one large computer complex. The approach used to develop and evaluate the software includes:

- identifying scenarios typical of major design tasks
- establishing performance criteria to be met for each scenario
- utilizing the software to conduct scenarios
- measuring achieved performance and improving software as necessary

Upon completion of sufficient evaluation, the software will be released to industry through ITAB.

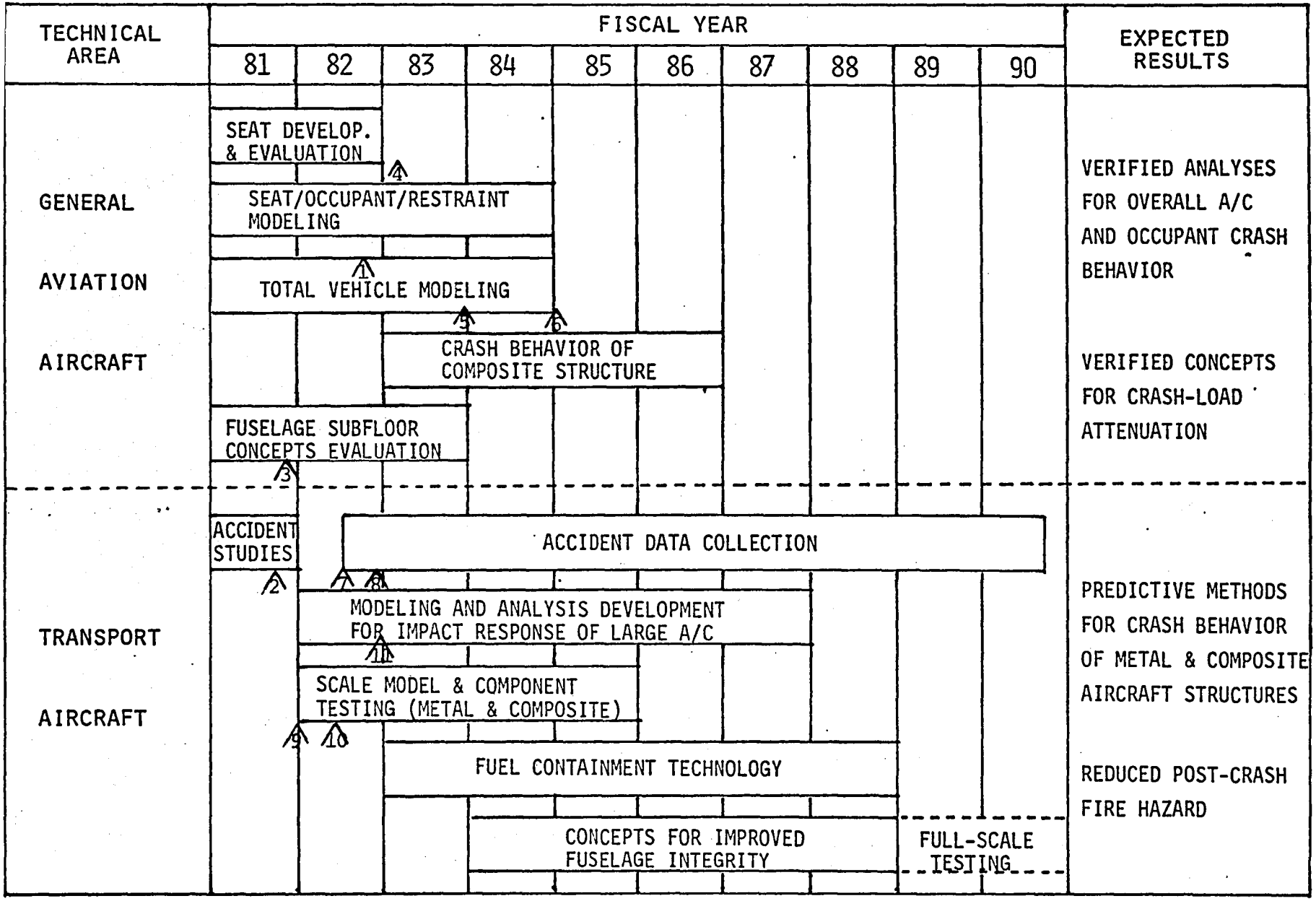
Supporting research under RTOP 505-33-63 will provide improved in-house capability in related computer-aided design areas. Consulting expertise will be provided by ICASE and GWU.

MILESTONES

1. Initial IPIP (version 2.0) operational
2. IPIP 2.0 available for evaluation
3. Initiate assessment of DEC VAX implementation
4. Select IBM subcontractor

III IMPACT DYNAMICS BRANCH

IMPROVED CRASH SURVIVABILITY



III IMPACT DYNAMICS BRANCH

RTOP 505-41-33 General Aviation Crash Dynamics
RTR 505-41-33-01 General Aviation Crash Dynamics

OBJECTIVE:

Develop and demonstrate new structural concepts and design methods for improved crash safety of general aviation aircraft

EXPECTED RESULTS:

- o Define and demonstrate improved static and new dynamic seat test methods in FY 1981
- o Analytically and experimentally verified by FY 1981 concepts for general aviation seats that will reduce loads on the occupant by 50 percent in crash conditions where the fuselage remains essentially intact
- o Complete determination of crash loads by tests of general aviation aircraft at speeds up to 90 mph in FY 1982
- o Complete integrated computer code for combined analysis of seat/occupant/restraint system by FY 1982
- o Develop and demonstrate load-limiting concepts for the lower fuselage structure of general aviation aircraft by FY 1982

APPROACH:

Nonlinear analysis methods developed in-house and on contract will be evaluated by correlation with results from full-scale crash tests of general aviation aircraft and aircraft components and by laboratory experiments conducted in-house. Improved static and new dynamic seat test methods will be defined and demonstrated on various general aviation seat configurations. Concepts for seat and restraint systems with improved load-limiting characteristics will be developed in-house and on contract. The most promising concepts will be fabricated on contract and tested in-house and at CAMI's (FAA) sled test facility using the new static and dynamic seat test methods. Load-limiting concepts for incorporation into general aviation airframes will be developed in-house and on contract. They will be designed by in-house static and dynamic load-deflection testing and the most promising concepts will be incorporated into aircraft fuselage sections for evaluation by full-scale crash testing. Select full-scale demonstration crash tests will be performed with modified Navajo fuselages incorporating load limiting subfloor and seat designs.

MILESTONES:

/2\ Initiate study with FAA and NTSB to acquire field accident data on seat and subfloor structure behavior in general aviation crash

/6\ Conduct three general aviation full-scale crash tests (Aztec, Gulf-Stream Cougar, Navajo) with modified subfloor and energy absorbing floor-mounted seat

/3\ Predict nonlinear dynamic response of two of the more promising subfloor concepts using DYCAST computer program

/1\ Predict nonlinear dynamic behavior of conventional and load-limiting seat configurations using improved seat/occupant/restraint system computer program

/4\ Fabricate and test (static and dynamic) 2nd generation floor wire-bending seats

/5\ Incorporate two of the more promising load-limiting subfloors into Navajo fuselages for full-scale demonstration crash testing

IMPACT DYNAMICS BRANCH

RTOP 505-33-53 Loads, Aeroelasticity, and Structural Dynamics
RTR 505-33-53-05 Transport Crash Dynamics

OBJECTIVE:

To understand and improve crash dynamic behavior of transport aircraft

EXPECTED RESULTS:

- Define by end of FY 1981 a transport crash dynamics program that identifies the research areas, test techniques, and analytical methods needed to assure a high level of transport crash safety
- Provide technology base to understand structural response of transport aircraft under potentially survivable crash conditions by end of FY 1983
- Define structural concepts for fuel containment in metal and composite wing structure by end of FY 1985

APPROACH:

Contracts with the three leading transport aircraft manufacturers will define typical crash conditions for transport aircraft in landing and takeoff accidents that should be accounted for in aircraft design. Nonlinear analysis techniques potentially suited to integration into design methods will be selected for study, and analyses of both metal and composite structure performed. From studies of load-limiting structures, the most promising seat and fuselage concepts will be selected, and experimental evaluations with laboratory-scale models and component aircraft sections will be conducted. A few select large-scale crash tests will be performed to demonstrate the degree to which improved personnel safety can be achieved in civil transport aircraft.

MILESTONES:

7 Complete study contract to improve occupant survivability in transport aircraft crashes

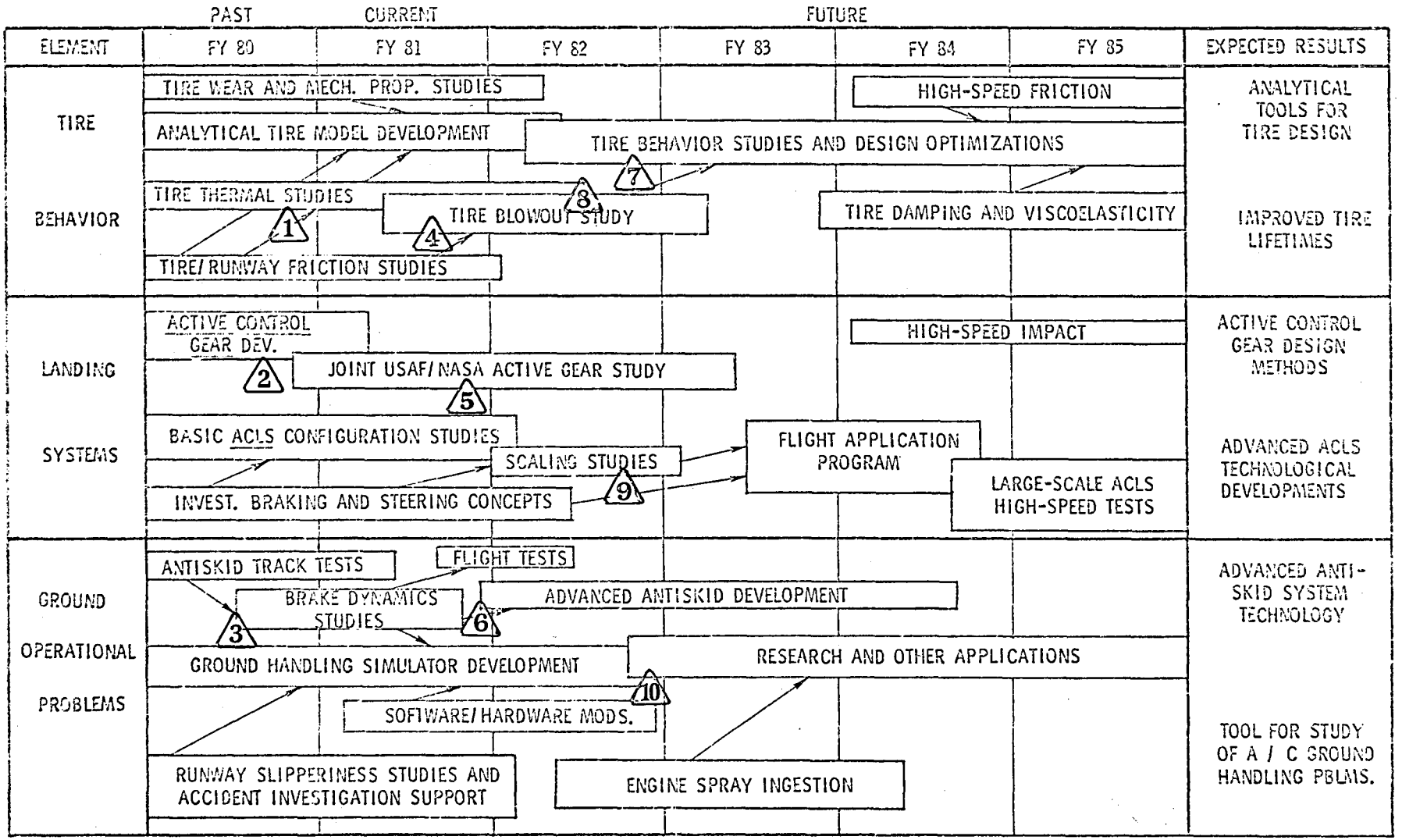
10 Design, fabricate and install vertical test apparatus to test transport sections

11 Modifying SOMLA to include finite element (DYCAST) multiseat and floor capability

8 Initiated joint FAA/NASA/NTSB special accident investigation team plan

9 Tearing, abrasion, crushing, compression and shear tests of composite coupon and element specimens

LANDING DYNAMICS PROGRAM LOGIC



IMPACT DYNAMICS BRANCH

RTOP 505-44-33 Aircraft Loading Systems Efficiency Improvements
RTR 505-44-33-01 Aircraft Ground Performance

OBJECTIVE:

Advance the technology for safe, economical all-weather aircraft ground operations including the development of new landing systems

EXPECTED RESULTS:

- Complete evaluation of elastomeric compounds aimed at improving the lifetimes of aircraft tire treads in FY 1981
- Complete development of analytical tire model by FY 1982 and implement optimization procedures to facilitate computer-aided tire designs
- Conclude program to evaluate thermal effects on tire carcass strength in FY 1982
- Define effects of blown tires and failed wheels on aircraft runway performance by FY 1983
- Develop and validate a software simulation of active control landing gear behavior by FY 1983
- Complete ground test phase of an advanced air cushion landing system in FY 1982
- Complete track study of operating characteristics of braking systems and initiate corroborating flight tests in FY 1981
- Complete modified flight simulator for research on aircraft ground operational problems in FY 1982

APPROACH:

Tire Behavior.- The analytical tire friction model will employ a shell finite element approach wherein the frictional characteristics are derived from assumptions based upon current knowledge of tire, surface and gear system characteristics. Experimental research, using instrumented ground test vehicles, the landing loads track, and full-scale aircraft, will be directed toward investigating the wear and traction behavior of new tread materials which offer potentially longer tire lifetimes. Other experiments, supported by analysis, will define tire temperature profiles under various operating conditions and explore the effect of elevated temperatures on tire carcass strength.

Landing Systems.- The approach for establishing the technology for developing an air-cushion landing system will consist of scaled model tests using the air-cushion test vehicle, complemented where possible by analytical studies, and full-scale track and flight tests to verify the design. The approach for studying active control gears consist of developing the analysis for designing such systems and validating the program through experiments both at the Landing Loads Track with modified gears and subsequent flight tests.

Ground Operations.- Research will be directed toward: (1) evaluating the traction characteristics of pneumatic tires on all types of runway surfaces, (2) developing techniques for measuring runway slipperiness attributed to various contaminants, specifically in terms of aircraft stopping distances, (3) expanding current flight simulator capability to permit the study and solution of aircraft directional control problems on runways, (4) studying the performance of currently operational, as well as advanced, antiskid braking systems, and (5) evaluating landing gear behavior and aircraft ground performance following tire blowout(s) and/or wheel failure(s). Research will also be conducted on other ground operating problems as they arise.

MILESTONES:

1 Complete evaluation of new tire tread elastomers

4 Conduct tire blowout studies on instrumented gear

5 Initiate track tests on active gear for tactical aircraft

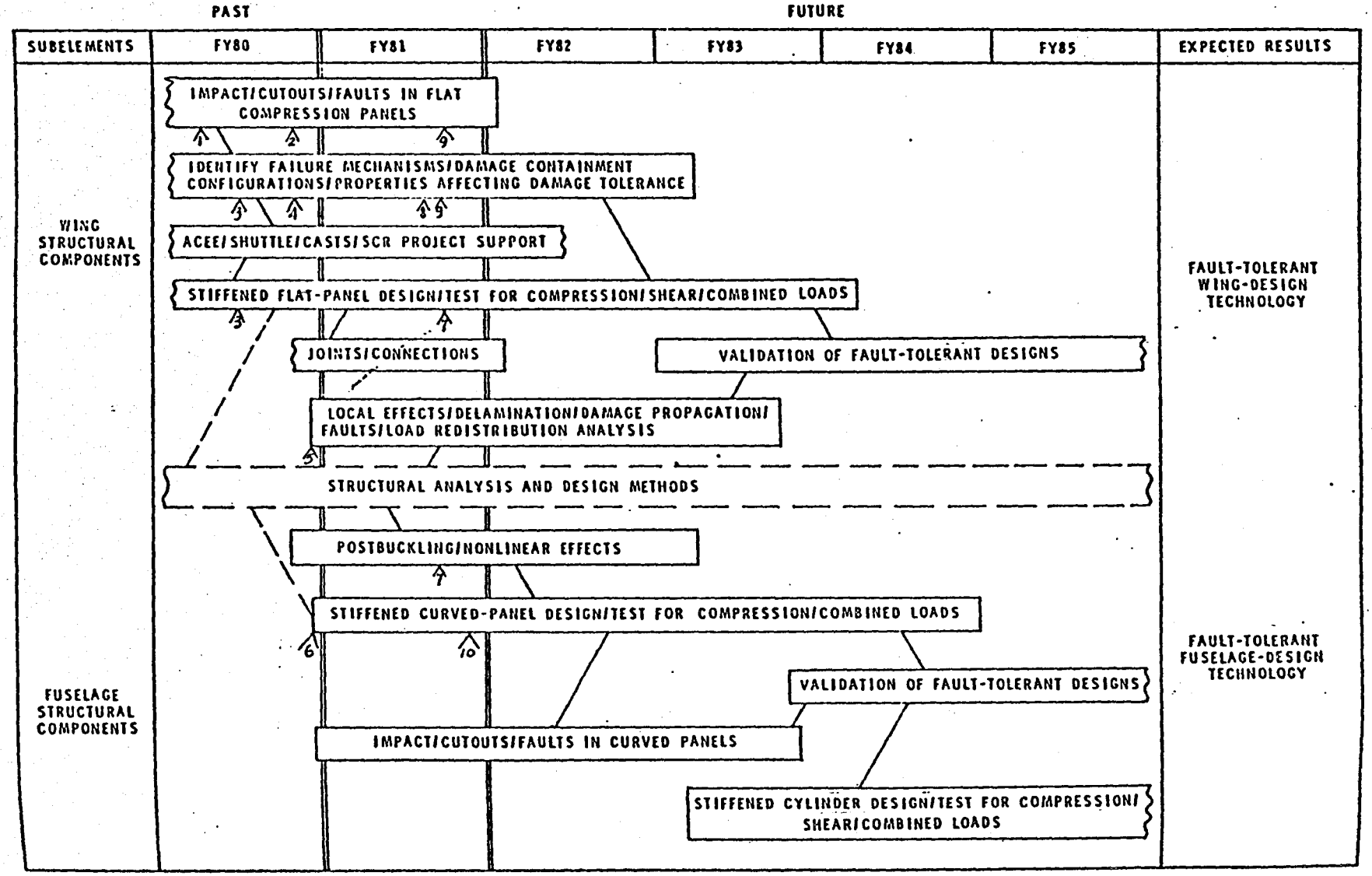
6 Complete brake dynamics study

10 Commence antiskid simulation study

Commence construction for track update, summer 1981

IV STRUCTURAL MECHANICS BRANCH

COMPOSITE STRUCTURES DESIGN TECHNOLOGY



IV STRUCTURAL MECHANICS BRANCH

RTOP 505-33-33 Composites
RTR 505-33-33-06 Composite Structures Design Technology

OBJECTIVE:

Develop mechanics technology required for design of efficient, fault-tolerant advanced-composite aircraft structural components subject to combined loads, impact, postbuckling effects and local discontinuities

EXPECTED RESULTS:

- o 50% improvement in design ultimate compression strains in composite components in FY 1982
- o Understand mechanics of buckling and the effects of flaws on strength prediction, and determine resin properties critical to damage tolerance in FY 1982
- o Understand effects of faults and impact damage on stiffened fuselage panels subject to combined loads and develop sizing methods and fault-tolerant concepts in FY 1983
- o Develop and verify damage-containment concepts for stiffened compression panels in FY 1984

APPROACH:

The advanced structural concepts and configurations that exploit the advantages of composites as well as advanced design methods for advanced composite flat and curved panels and stiffened shell structures will be developed. Compression, tension, shear and combined loads representative of aircraft primary wing and fuselage components will be considered. Methods will be developed for predicting strength, buckling and stiffness of composite components including the effects of foreign-object damage, cutouts and postbuckling. An experimental data base will be established for composite airframe structural components including damage, cutouts and postbuckling and correlated with analytical predictions.

MILESTONES:

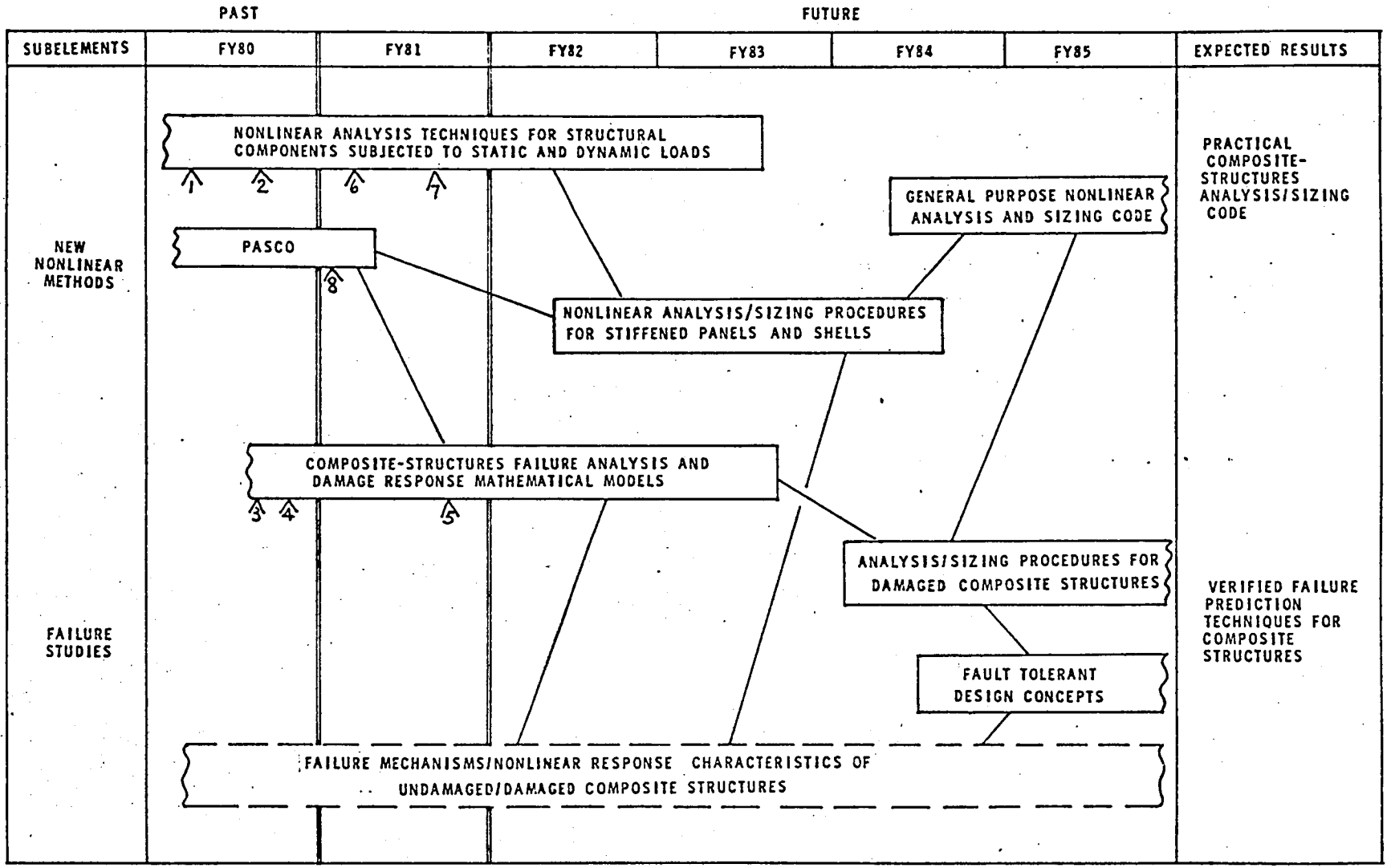
7A Complete preliminary postbuckling study of stiffened compression panels, December 1980

8A Complete preliminary study of damage arrestment concepts, July 1981

9A Complete screening tests of alternate matrix materials and identify mechanical properties that affect damage tolerance, August 1981

10A Complete subcomponent test program for pressurized-fuselage stiffened-panel specimen, September 1981

NONLINEAR STRUCTURAL ANALYSIS AND SIZING METHODS



STRUCTURAL MECHANICS BRANCH

RTOP 506-53-53 Failure and Thermal Analysis
RTR 506-53-53-03 Failure Analysis

OBJECTIVE:

Develop structural analysis and sizing methods for predicting and designing for nonlinear behavior of aerospace structures including ultimate strength and postbuckling phenomena

EXPECTED RESULTS:

- o Develop new nonlinear algorithms for postbuckling, reduced degree-of-freedom, and time integration analysis. Improve nonlinear methods for predicting ultimate strength of composite structures accounting for observed laminate failure modes in FY 1982
- o Develop new dynamic collapse computational procedure by FY 1984
- o Preliminary assessment of weight saving that can be achieved by exploiting postbuckling strength of composite structural panels in FY 1982
- o Pilot nonlinear analysis and sizing procedure for structural components. Analysis and sizing techniques are integrated for efficiency in FY 1984

APPROACH:

A failure prediction technique will be developed and validated for a general flawed laminate considering lamina level failure modes. This technique will permit the rational design of arbitrary laminates with a minimum amount of testing. This failure prediction technique will be coupled with structural analysis codes for predicting the ultimate strength of complex, built-up structures.

A numerical procedure, based on perturbation theory, will be developed to integrate past the critical points of nonlinear structural response problems. The procedure will be incorporated into an existing nonlinear structural analysis program and applied to determine the postbuckling strength and residual strength of general structural components.

Automated methods will be developed for generating global functions that transform structural transient-response problems into equivalent mathematical models with a reduced number of degrees of freedom. These models will be implemented into a digital computer program to increase computational efficiency and to decrease the cost of solving nonlinear transient-response problems.

MILESTONES

5 Complete development of and validate a finite-width, flawed laminate failure prediction technique, July 1981

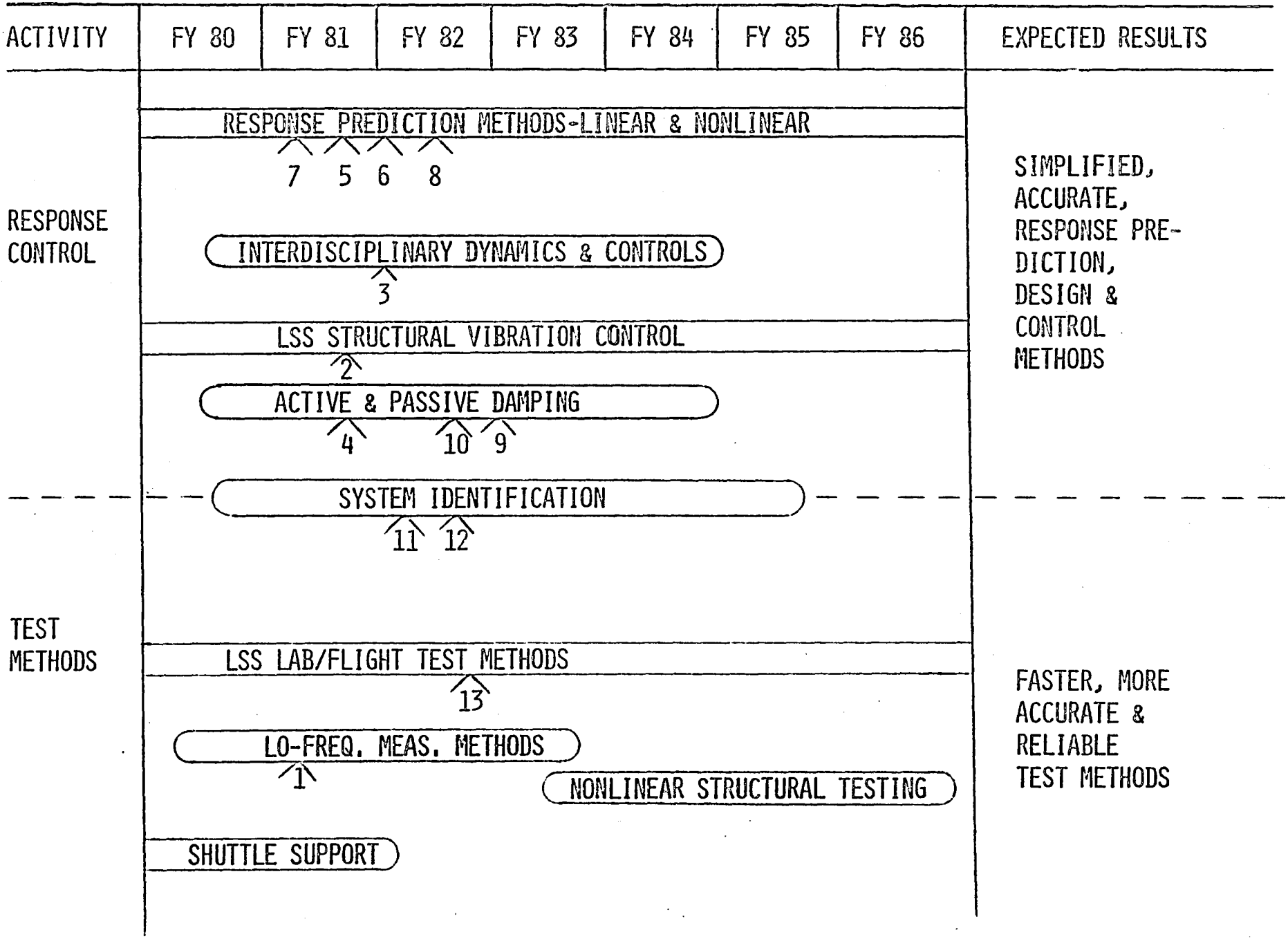
6 Demonstrate use of mixed finite elements with reduced basis method, August 1981

7 Demonstrate general computational capability using reduced basis techniques (STAGS), September 1981

8 PASCO panel analysis and sizing code being distributed to U.S. aerospace companies, workshop held July 1981

V STRUCTURAL DYNAMICS BRANCH

SPACE VEHICLE DYNAMICS



V STRUCTURAL DYNAMICS BRANCH

RTOP 506-53-63 Loads, Dynamics and Aeroelasticity
RTR 506-53-33-01 Space Vehicle Dynamics

OBJECTIVE:

Develop and validate analysis and test methods for the prediction and verification of structural response and stability in dynamic environments for use in the support of advanced design optimization of space transportation systems and payloads

EXPECTED RESULTS:

- Develop and validate by end of FY 1983 improved methods for the prediction of space vehicle dynamics
- Develop by FY 1983 methods for predicting and reducing the response of large space structures to dynamic inputs
- Establish by end of FY 1981 improved methods for dynamic (modal survey, environmental) testing of space vehicles, payloads and components, so as to reduce testing times by 50% and testing costs by 30%
- Develop by end of FY 1983 vehicle/payload dynamic environment prediction techniques for low-frequency dynamics. Validate these techniques by end of FY 1983 using measured data from a shuttle payload

APPROACH:

In the structural dynamics area methods for automated improvement of finite element models with the use of vibration test data will be studied. Theoretical studies of active damping of large flexible structures will be continued. A focus experiment to validate theoretical trends will be developed using a flexible beam.

The use of digital processors, (including array processors) will be employed for test control and in the acquisition and on-line analysis of measured vibration data. To handle low-frequency structural vibration, methods of remote tracking of optical targets and the subsequent coordinate transformation processing will be implemented. A prototype self-powered target will be designed, fabricated and tested.

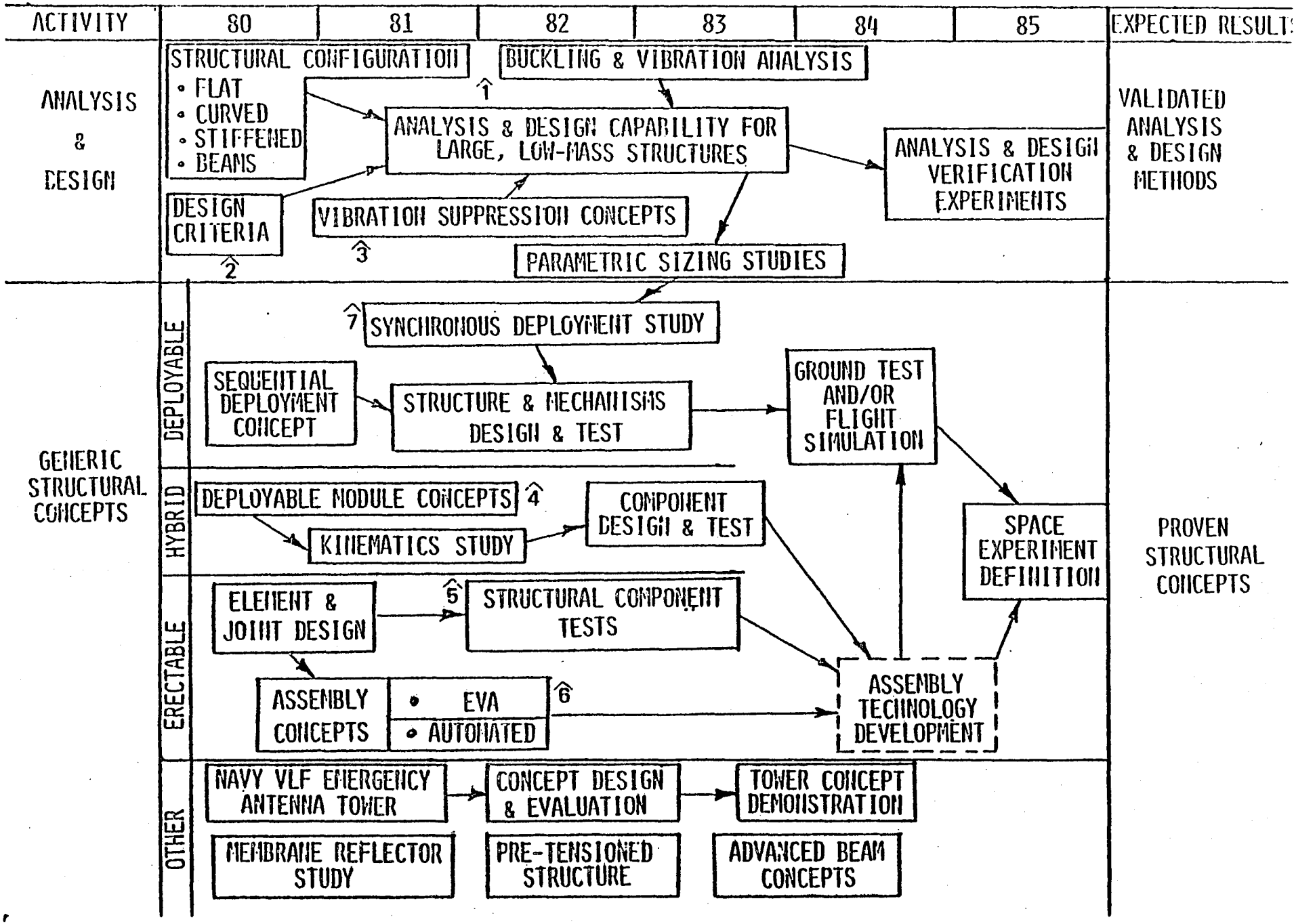
In the controls area, theoretics of adaptive/learning control and control dynamics for flexible bodies in orbit will be investigated. A simulation of the Solar Electric Propulsion (SEP) array attached to Shuttle will be used to evaluate performance of structural dynamics and control algorithms. As the active damping experiment is developed, studies of sensor characteristics and actuator excitation levels will be investigated to develop a complementary controls experiment.

Milestones:

1. Deliver optical target prototype
2. Perform closed loop simulation of adaptive/learning system
3. Review university interdisciplinary dynamics/control studies
4. Define active damping experiment
5. Complete analysis/test study of tension stabilized beam
7. Develop and validate unidirectional nonlinear dynamic analysis of SIP

VI STRUCTURAL CONCEPTS BRANCH

ADVANCED SPACE STRUCTURES



VI STRUCTURAL CONCEPTS BRANCH

RTOP 506-53-43 Advanced Space Structures
RTR 506-53-43-01 Advanced Space Structures Research

OBJECTIVE:

Develop the analysis and design methods, structural concepts and assembly technology required for the construction of large spacecraft

EXPECTED RESULTS:

- o Validate analysis and design capability for large spacecraft by end of FY 1983
- o Verify deployable concepts which permit orbiting spacecraft of 200-meter span in one Shuttle flight by end of FY 1983
- o Prove erectable concepts for structures of 100- to 1000-meter span by end of FY 1983 and assembly methods by end of FY 1985
- o Prove concepts for precision reflector structures (RF) which are 10 times more accurate than current reflectors by end of FY 1984

APPROACH:

In the structural concepts area, folding and packaging techniques for very lightweight deployable structures will be investigated. The effects of using very slender members to achieve high packaging efficiency will be evaluated. A truss structure will be constructed for static and dynamic tests to confirm theoretical predictions.

Design efforts will be focused on studies of a large, faceted antenna concept. Studies of achievable accuracy in construction, and techniques of assembly of deployable modules will be investigated. Selected problems in construction/operational dynamics will be performed. The effects of orbital transfer thrust loads on structural sizing will be investigated.

In the erectable structures area, work will be completed on static and dynamic characterization of a large tetrahedral truss structure subelement. Assembly tests in MSFC's Neutral Buoyancy Chamber will be conducted to construct a linear structure of nestable columns. The tests will address the use of EVA together with simplified mechanical construction aids to permit evaluation of mobile work station concepts.

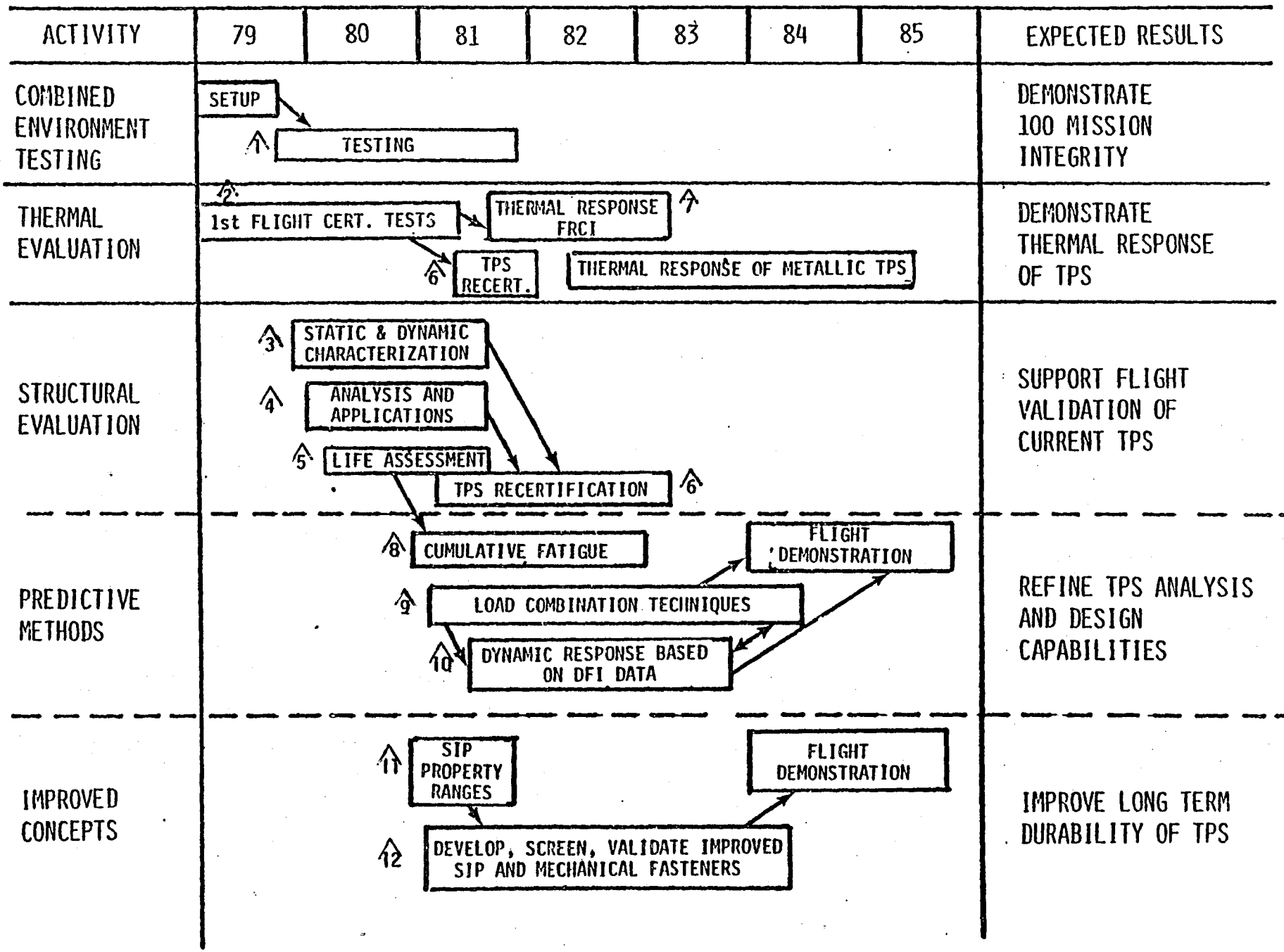
MILESTONES:

5 36 - element truss test

6 NBF/EVA assembly experiment

7 Low - mass deployable truss segment tests

NONMETALLIC TPS CONCEPTS



STRUCTURAL CONCEPTS BRANCH

RTOP 506-53-33 Thermal Protection Systems for Earth-to-Orbit STS
RTR 506-53-33-06 Nonmetallic TPS Research

OBJECTIVE:

To evaluate and improve the structural performance and expected lifetime of nonmetallic ceramic reusable thermal protection systems

EXPECTED RESULTS:

- o Complete 100 cycles of shuttle combined environment testing in FY 1981
- o Define allowable mechanical property stiffness ranges for usable SIP by late FY 1981
- o Develop nondestructive in situ test procedures to evaluate TPS reusability by late FY 1981 with refinements by late FY 1982
- o Develop and validate a cumulative fatigue life prediction rule for TPS with densified RSI by early FY 1982
- o Complete a dynamic analysis of TPS using postflight developmental flight instrumentation data by early FY 1982
- o Develop SIP concepts with higher strength and longer life and mechanical attachment concepts by mid FY 1982

APPROACH:

The activity will support the Shuttle program by conducting critical tests and analyses needed to understand the response of the tile-strain-isolator-pad (SIP) system. Static tests will be conducted to characterize the nonlinear behavior of the system with respect to lateral pressure loads and moments. Dynamic tests will be conducted to character tile response to sinedwell and random loading inputs. Studies of cyclic and random fatigue response will be conducted. Analytical models accounting for nonlinear and hysteresis response of the SIP will be developed for static and dynamic response prediction. Analysis will be used to predict stresses and dynamic stress concentration for comparison with test results. With the knowledge of tile-SIP behavior established, efforts will be made to develop improved SIP concepts, to predict cumulative fatigue behavior, and to perform meaningful post-flight tile inspections.

MILESTONES:

1. Complete 100 missions with two test panels, September 1981
2. Complete TPS thermal certification tests for 1st flight, February 1981
3. Complete structural characterization of TPS, March 1981
4. Develop nonlinear static and dynamic analysis techniques, April 1981
5. Evaluate expected life of TPS, July 1981

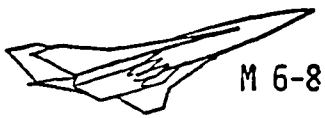
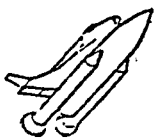
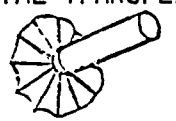
STRUCTURAL CONCEPTS BRANCH

RTOP 505-33-73 High Temperature Aeronautical Structures
RTR 505-33-73-06 Hydrogen Cooled Scramjet Structures

OBJECTIVE:

Research and development through analyses and tests of efficient high temperature structural concepts critical to the design of future aerospace transportation systems

TECHNICAL OPTIONS:

TECHNICAL THRUST	FY 81 THROUGH 91	EXPECTED RESULTS
HIGH SPEED AIRCRAFT	M 4-5 AIRPLANE   M 6-8 HYPERSONIC TRANSPORT	VALIDATE CONCEPTS FOR JP/METHANE RAMJET AND LH_2 SCRAMJET AND PRIMARY STRUCTURES
SUPERSONIC TRANSPORT	 M 2-3 LONG LIFE	VALIDATE FUSELAGE AND WING PRIMARY STRUCTURES
SHUTTLE DERIVATIVES	 MORE DURABLE TPS LOWER WEIGHT PRIMARY STRUCTURE	VALIDATE DURABLE TPS DEMONSTRATE LOWER WEIGHT STRUCTURES
ADVANCED SPACE TRANSPORTATION SYSTEMS	ORBITAL TRANSFER   HEAVY LIFT	DEFINE STRUCTURAL CONCEPTS FOR OTV AND REUSABLE CRYOGENIC TANKAGE

MILESTONES:

Perform weight-efficiency studies of lightweight panel concepts for reducing wing-weight in hypersonic airplane

Perform parametric study of cooling requirements for engine chamber of hypersonic airplane

Conduct tests for creep, strength, fatigue and crack growth of welded and diffusion bonded Ti-6-2-4-2 with/without joints

Tests for creep, strength, fatigue and crack growth of welded and DB Ti-6-2-4-2, with/without joints, September 1981

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15. Supplementary Notes

16. Abstract

The purpose of this paper is to present the Objectives, Expected Results, Approach, and FY-81 Milestones for the Structures and Dynamics Division's research programs. This information will be useful in program coordination with other government organizations in areas of mutual interest.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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